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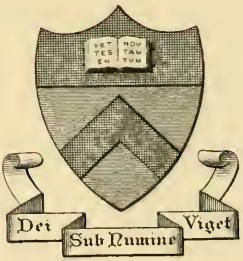

Princeton University.

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NOTES SUPPLEMENTARY

TO THE

ZOÖLOGICAL TABLES.

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LECTURE I.—*Explanation of Terms.*—Natural history or natural science, strictly speaking, includes the study of all natural objects, animate and inanimate; but it is usually restricted to the science which deals with plants and animals. Biology is philosophic natural history, and includes zoölogy, the study of animals, and botany, the study of plants. Anciently, natural history dealt with external appearances; anything that could fly was a bird; swimming animals were fishes, &c. This is still the popular system, and is correct as far as it goes, but is in the highest degree superficial. We now regard and investigate internal structure. Points of agreement and difference may be accidental, and points of harmony may be concealed. It is the naturalist's business to determine what points of agreement and difference are the most important, and to discover those which may be hidden.

The advantages of natural history, following from such an investigation are, (1) an enjoyable study; (2) trains the powers of observation; (3) providing a great store of likenesses and unlikenesses, it enables us to classify better; (4) it is in itself very important; very many of the most important questions of the day are dependent upon, or related to, natural history. Even psychology is beginning to be studied in connection with observations on the brain, as to its control over the various functions of the body; it has been found that the cerebellum governed muscular movement, the cerebrum mental activity.

Method of Investigation.—Object. To find out where animals agree and differ ; then to estimate the proper value of these agreements and differences, and to arrange accordingly :

1. As to man. The so-called vertebrate theory of the skull was first stated by Goethe, who, upon finding a sheep's skull, noticed that it was not a solid bone. He made use of this in a fanciful way, assuming it to be true of man. Oken went further ; he asserted that the skull was really four extra vertebræ, which he named the frontal, parietal, nasal and occipital. Owen went still further ; he found a larger number of segments than four, and actually constructed an imaginary archetypal skeleton, to which all skeletons were referred ; this was going too far ; we shall study man as the type.

2. Compare different animals. This is comparative anatomy. For a long time a vast difference was noticed between man's skull and that of animals, in that while man has but one superior maxillary, animals have two, separated by a middle or pre-maxillary bone. This fact was for a long time a stumbling-block, but it has been removed by finding the bone present in the human embryo, but in a later condition, becomes coössified with the maxillary bone. This, and other points, to be noticed hereafter, go far to establish the theory that all vertebrate animals are constructed on the same general plan.

3. *Method of comparing,*

a. Adult form—comparative anatomy ; *e. g.*, human skull and that of alligator, and trace points of agreement and difference.

b. Rudimentary structure ; that is, structures small in one animal, but large and important in another ; *e. g.*, in man, the fibula is a distinct bone of the leg ; in the hind-leg of the horse its place is supplied by only a little piece of bone at the joint. In birds are traces of fibula and tibia, but the fibula coalesces with the tibia. From the existence of these rudiments we see the relations of animals. Again, the horse has but one toe, yet there are two small pieces of bone called splint-bones, which are at the joint, and correspond to two more toes, thus showing relation of horse to three-toed animals. In man, we notice on the scapula a process called the coracoid ; in birds, fish, and some reptiles

there is a separate coracoid bone, and this process in man is a coössified bone with the scapula; it is *rudimentary* in all mammals. Man has the rudiments of a tail, coccyx; a slight enlargement on the lobe of the ear suggested to Darwin a relationship to monkeys and other long-eared animals.

c. Abnormal or monstrous growths. A horse has been found with three toes. This proves that the rudiments mentioned above do really correspond to toes. A fish was caught with two mouths. This shows probably some fundamental structure, the gill-arches being equivalent to mouths. Deer and hogs have been found with uncloven feet; sheep and hogs have been found with hair. Some monstrosities are meaningless, as two-headed calves, &c. Man exhibits few, but remarkable monstrosities. A child's skull had a bone extending from the inner surface of the inferior maxillary to meet a process from near the ear. This bone exists in birds and some reptiles.

d. Fill up gaps from palæontology and newly-discovered animals. The science of palæontology often renders valuable service in this connection, and the discovery of new animals is a constant source of information, *e. g.*, the opossum was formerly classed with the hedgehog, but the discovery of the kangaroo decided its true position. The duck-billed platypus unites characteristics of the duck and mammal. An animal of New Zealand unites those of frog and bird. A fish has been discovered without either head or heart. A great point of difference between birds and other vertebrates is, that birds have no teeth. Here palæontology comes in with a fossil bird having teeth. A pliocene fossil horse (hipparion,) with three toes, has been found in America.

e. Embryology, or tracing development from the egg; since, to thoroughly understand an animal, we must know its history from the beginning. Here the science of embryology is of vast importance, but owing to its difficulty, and the time and skill required, very little has been done. It points out marvelous points of agreement; *e. g.*, birds and whales have embryonic teeth. The skulls of man and fowls are somewhat alike in the egg, but as they grow, parts coössify in the one, which remain

separate in the other. The same may be said of man's skull and that of the fish. These embryos must be taken at a very early stage, for the skull of man, since it must reach such a high development, develops very rapidly. The great embryologist, Parker, in his investigations on the head of the common fowl, found that its skull, in its earliest stages, resembled that of the fish ; a little later, that of the turtle ; later, that of the ostrich ; then, that of a peculiar South American bird, somewhat like a turkey ; next, the skull of a grouse. He says his experience was like that of a maker of a palimpsest, a manuscript with double writing. Another time he procured sixty-five young pigs in every stage of development, some only one and a half inches in length. He first hardened them with potassæ bichromas ; then he cut them into thin laminæ, every possible section being taken and arranged for the microscope. Beginning with the adult and going backward, he found that the earliest skull resembled that of a fish ; then in succession that of a frog, fowl, mammal, and, finally, the marks of order and species began to appear. Thus we see, that all animals start alike ; the snake is but an undeveloped lizard.

General Result—1. Deep harmony in structure. All our investigations go to show that there is a great harmony of structure in animals ; many theories exist to account for this. Some say it can be explained by the theory of descent ; others, that there is a common plan ; others, that these are merely strong points of agreement. But, whatever theorists may say, we must have facts, and the great fact is, that there is great unity of structure and continuity of form.

2. It is dangerous to draw rigid boundary lines. No one can tell just where vertebrate structure ends and invertebrate begins ; where animals and plants are limited. All attempts to fix the boundaries of instinct and reason have failed, or, to tell where an independent life begins in the egg, or even to define life. We must deal with *structure*, not function, (homology.) The alligator's tail and the frog's legs are widely different in structure, but their function is the same, *i. e.*, swimming. Likeness of structure is called homology, and like parts are homolo-

gous, *e. g.*, for a long time the tusks of elephants and walruses were deemed homologous, but they are not; those of the elephant are incisors; of the whale, canines.

LECTURE II.—All animals are included in the one term, animal kingdom. The most important divisions under this are called sub-kingdoms, and these are divided into classes. The sub-kingdom we are now considering is the vertebrate, and includes the following classes: (1) mammalia, (2) birds, (3) reptiles, (4) batrachians, (5) fishes.

1. *Characteristics of Vertebrate Animals.*—They are, as all other animals, produced from eggs. An egg is a cell containing a nucleus, and within this a spot called the nucleolus, *e. g.*, the spawn of a frog. The egg of the fowl differs, in having with the germ-cell a supply of food; the germ-cell lying directly on the top of the yolk. Mode of development from the egg:

1. (Taking the egg of a frog,) we see that it is a little sphere, about one-half of which is dark and the other light; the dark part becomes the outside of the animal, the light, the inside. The first is, that one cell is divided into two, by an equator, or ring. It then becomes still more divided by meridians, more numerous on the dark than on the light side; then it becomes still more divided-up, especially the dark side, where development is more rapid. After this division two courses of development may be followed: (1) the cells may separate and each part become a distinct animal. These are the very smallest and lowest animals, and are called protozoa, consisting of but a single cell. (2) The cells may hang together and form a composite structure. These are called metazoa, and include all animals, from the sponge to man. The name is a collective one for all many-celled animals. As these cells divide, they enclose a cavity, surrounded by a single wall of cells. This is called a morula (mulberry.) The cells again subdivide, and, becoming more numerous, grow over the others, thus forming a double wall over the cavity. This is called the gastrula. These are, of course, accompanied by a food-supply, which is sometimes

inside, as in the case of the frog, or outside, in a bag in the fish.

2. *Yelk Division of Egg.*—The young germ is called blastoderm ; and as it develops from the gastrula, there is seen a fold at one end for the head, another for the tail, and in vertebrates, running up the middle of the body, there is a furrow. This dorsal furrow is the first mark of a vertebrate animal. The yelk becomes the food-supply.

3. *Embryo of Three Layers.*—The germ now becomes triple in structure, consisting of three layers. There is an outer layer corresponding to the outer layer of cells. This is called the epiblast. The inner layer, which may be termed the food-layer, is called the hypoblast, and the middle flesh layer is called the mesoblast.

4. *Ventral Aspect of Embryo towards Yelk.*—The embryo always has its stomach towards the yelk from which it receives its food-supply.

5. *Mode of Development from Germ Layers.*—The outside dorsal-fold grows deeper until it is gradually enclosed above by the sides joining. The skin thus enclosed secretes nerve-matter ; thus the skin forms the brain and nervous system. This canal in which the nervous matter is formed, is filled with a liquid, and in man the brain never entirely fills its cavity, but floats in this liquid. The nervous matter is generally collected in the largest quantities where the various animals need it most. Thus, man's brain is very large, while in the crocodile the greatest quantity of nerve-matter is collected near the tail. The whale, however, although using the tail very much, has a very large brain. The nervous system of vertebrates is dorsal ; of invertebrates, ventral. The inner layer, the hypoblast, forms the lining of the appendages of the stomach, liver, æsophagus, &c., *i. e.*, the viscera, so that the hypoblast always remains near the food. The mouth and anus are formed by the skin folding in to meet the intestines. The middle layer, mesoblast, divides into two sheets ; the upper forms the body wall, flesh and bones ; the lower, the walls of the alimentary canal, with lungs, liver, pancreas, &c. The cavity between the two sheets is the body cavity.

6. *Skeleton.*—The skeleton is a secondary growth. The first indication is a rod of membrane running up through the body, and called the dorsal chord or notochord. This is found in all vertebrate animals; some as the lancelet never reach a higher stage. Something resembling this is also found in invertebrates. This sheet of notochord becomes vertebral in a series including vertebræ, ribs, shoulder, pelvic arches, limb bones, &c.; also the skull with roof floor, underjaw. In fish the fins (certain of them) correspond to limbs. The cod-fish has his hind legs under his throat!

7. *Visceral Arches and Clefts.*—In the neck of the embryo are observed various arches and clefts. In tadpoles and fish the front ones become the gill arches, the jaws and spiracles. Prof. Mackloskie's theory is that these arches which exist in all vertebrate animals represent ribs, and that our jaws and eustachian tube are the remains of these arches and clefts, and that the latter represent the spiracles of the fish; also that the hyoid bone and Adam's apple are traces of these arches.

(For further characteristics (8–16) see printed tables. Prof. Mackloskie merely mentioned what is there stated.)

Lecture III.—*Vertebrate Classes—Sub-Kingdom I.—Vertebrate.* —Cuvier did most toward arranging vertebrates into classes. He dissected, compared and made a classification which remained in use until two years ago, when it was modified; the classes we have to-day may be different next year. At present the classes are mammals, birds, reptiles, amphibians, and batrachians and fishes. The lancelet is a vertebrate without a head, and the lamprey has no under jaw, but has a head.

Characteristics distinguishing mammals, birds and reptiles, from batrachians and fishes.

1. In mammals, birds and reptiles, the respiration is by lungs only; they have no gills. Some fishes, and all batrachians, have gills and lungs, while fish generally have gills only. The batrachians undergo great changes; when young, a frog swims, and the stomach of a tadpole is coiled like a watch spring; when uncoiled it is two feet long; when

older it loses its gills and gets lungs ; it can breathe under water through its skin. A certain batrachian of Mexico never loses its gills in its mountain home, but when removed it loses them. The gills are for obtaining oxygen from the water, which is not only an element of water, but some oxygen in the air becomes mingled with the water, and it is this oxygen alone the fish can breathe ; they cannot extract oxygen from the water. Some fishes breathe on the land by means of their gills, in which they carry water.

2. *The Amnion Around the Embryo with Fluid in which the Embryo Floats.*—The amnion is a continuation of the body wall, forming a sac filled with a fluid in which the young animal floats. Mammals, birds and fishes only have an amnion.

3. *Allantois for Embryonic Respiration.*—The allantois (a bud) is a little sac budding out from the back part of the alimentary canal ; it is for embryonic respiration.

4. *Printed Tables.*—The kidneys characterize high vertebrates.

5. *Printed Tables.*

6. *Printed Tables.*—Habit of living will not always guide in classification ; *e. g.*, some fishes live in the air ; bats are not birds, but mammals ; the whale is not a fish—it is a mammal.

Characteristics distinguishing mammals, birds, from reptiles, batrachians, fishes.

1. *Number of Chambers in Heart.*—Mammals and birds have a double form of heart ; a right or respiratory heart, consisting of two chambers, sends blood to the lungs ; a left heart of two chambers sends blood to the system. Reptiles have a heart and one-half more ; *i. e.*, three chambers, two receiving auricles, but only one ventricle. The arterial is, in some way, always separated from the venous blood. A snake's heart, consisting of three chambers, is of a higher character than that of a turtle. The crocodile's heart consists of four cavities.

2. *Warm Blood.*—The temperature of the blood of mammals and birds is about 100° F. ; that of frogs and fishes is a little above the temperature of the water in which they live. Mammals, birds and some reptiles have warm blood ; all batrachians and fishes have cold blood.

Characteristics distinguishing mammals from birds and reptiles.

1. Mammals are viviparous ; birds and reptiles are oviparous or ovoviparous—*i. e.*, produce young from eggs hatched externally or internally. Some snakes, and most sharks bring forth their young alive ; *i. e.*, are ovoviparous. The eggs of mammals are very small.

2. *Provision of Food for Young.*—When the young are produced alive, they need food before birth. In mammals the allantois grows larger and spreads over the whole outside of the germ, and is called the placenta. Its purpose is to communicate between the blood of the mother and that of the embryo ; marsupials have no placenta ; the young are born imperfect ; a kangaroo six feet in height has young three-fourths of an inch long. In mammals a supply of milk is provided after birth.

3. *Printed Tables.*— Hoof of horse, &c. The scales of fishes cannot be thrown off.

4. *Teeth Mostly Complex.*—Complexity of teeth marks high groups. Some mammals have no teeth ; some have teeth all alike, as the armadillo, crocodile. The elephant's tusks are the incisors ; those of the walrus are the canine.

5. *Anatomical Characters—Printed Tables.*—One condyle gives freedom of motion ; two give strength. (For characteristics, 2–9, see Tables. We add under 2 that the quadrate bone of reptiles, which articulates the lower jaw to the skull, is the malleus of the ear in man ; the lower jaw is loosely hung in reptiles ; under 4. In mammals the planes in which the angles of the limbs are set are parallel to the vertical median plane of the body.) The distinguishing characteristics of birds and reptiles can hardly be deduced from the preceding. Batrachians have lungs and gills, and undergo great metamorphoses ; fish have gills only. Again, birds have one (right) aortic arch; reptiles have two such arches—right and left ; fish have several. The lancelet is peculiar ; it has neither head nor vertebral skeleton, the noctochord persisting ; the lamprey has no under jaw.

LECTURE IV., V.—*Mammalian Sub-Divisions.*—Of all animals, the mammals are the most important and interesting, and man has, of course, the greatest interest for us, but he is not the most instructive subject of study; the cat or dog is more so. The marks, briefly, of a mammalian skeleton are two occipital condyles—at the back of the head in the dog and cat, at the centre in man. A strong under jaw articulated with the head. Complicated ear; some of the bones of which, in reality, belong to the upper jaw (incus, malleus.) Absence of coracoid bone; scapula not attached to skeleten; the hind limbs firmly fixed to it. Skeleton made of dense bones, and by these we can recognize groups, presence of mammary glands, four-chambered heart, placenta, &c.

In dividing mammals into groups, we meet with three thousand five hundred species, two thousand one hundred being alive at present; three hundred and ten in America, north of Mexico. There exist three *natural* systems of classification, namely, Cuvier's, Owen's, and the one now commonly adopted. Cuvier's classification depended upon the examination of the adult structure of animals. It is still followed in a modified form. Owen classified animals according to the brain; in this he erred, as we should never confine our attention to a *single* organ only. He assumed man to be the highest, and found that in him the cerebrum overlapped the cerebellum. Then he placed the animals with cerebrum slightly more exposed, in the next group. Here, it may be remarked, that man surpasses monkeys in the development of the front part of the brain. Next come animals, with highly-convoluted brains, gyrencephala. Finally, animals with smooth brains, *e. g.*, the kangaroo. The true classification depends upon embryology, and the character of the placenta; man and monkeys have a circular placenta; carnivora have a band-shaped placenta; herbivorous animals have a spot-shaped placenta.

Binomial system of nomenclature. Under kingdoms and sub-kingdoms, come classes, which may be defined as a well-marked group, *e. g.*, carnivora, marsupials, &c. Families are groups still closer related. Carnivora include the cat family,

the dog family, &c. Genus is a group of species so closely allied as to agree in all main points. Cat belongs to the genus felis ; genera may vary in color, size, &c. The term species, includes those that agree in all points except trifles. In naming an animal, we write the genus in capitals, the species in small letters, and the initials of the naturalist who first classified the animal, *e. g.*, Falis, leo, L., denotes that genus is felis, the species leo, and that Linnæus first classified the animal.

I. *Primates—Man.* (See Tables.) In most parts of our structure, we find an agreement with monkeys, but man vastly surpasses them in intelligence. But this is a high group, with complex brains and teeth. Man is distinguished from monkeys by the great size of his brain ; thus it appears that a large brain accompanies great intelligence. Mosh, from a comparison of the brains of various animals, argues that is not an important feature, he having found animals of little intelligence in some cases possessing large brains. This seems, however, to be not true ; man, with his large brain, depends wholly upon it for existence. In the embryo the brain is, proportionally, larger than in the adult, as a further distinction from monkeys man walks upright ; variety in men does not prove diversity of origin. The color of the skin does not decide race; Caucasians are a Mongolian race ; some true negroes are white. Man is recent in origin, but the date of his appearance cannot be scientifically fixed. As to development, no single line of development between man and monkey can be fully carried out, and he is also clearly related to still lower animals, as the frog. Against the development hypothesis, we urge that ancient races are just like modern ; skulls like our own—high intelligence and skill. On a remote island in the Pacific are the remains of splendid statues ; in the mounds of Ohio are specimens of mathematical and artistic skill ; in a word, everything goes to show that man started in the world fully developed.

Monkeys.—(See Tables.) Order, quadrimana. Monkeys abound in the tropics, and are very much unlike in different

parts of the world. The old-world monkeys only have an ear channel; in those of the new world the tympanum comes to the surface; old-world monkeys have a very narrow division between the nostrils; new-world monkeys have a broad division.

Lemurs, (*half-monkeys.*)—Closely allied to monkeys; are confined to Madagascar and the East Indies. (See Tables.)

II. *Carnivorous Series.*—1. Dominant. Order, carnivora. Examples, lion, cat, dog, &c. These animals are of the tertiary period. Characteristics, all are precocious, intelligent, active, canine teeth strong, six incisors above and six below, lower jaw has its condyles set so as to give little freedom of side motion but great strength. The skeleton is very powerful. The under jaw of the dog is longer than that of the cat. The walrus and seal have their limbs organized for swimming. They are monsters of the world, under man; exceedingly useful as scavengers. All animals need protection from them, and there is little doubt but that some extinct species owed their destruction to the carnivora.

2. *Low Order, Insectivora.*—Examples, hare, mole, shrew, hedgehog, flying lemurs. These are in every way inferior to the carnivora, and all have some special means of protection. The mole burrows, the hedgehog has spines, the flying lemurs live in the trees; bats can fly, and all insectivora having no special means of protection, have perished.

The geographical distribution of animals furnishes a strong argument for unity of origin as regards locality. The great centres of distribution seem to have been North America, and Northern Europe and Asia, taken together usually under the name of Eurasia. From these centres they were distributed to other parts; this is proved by the fact that fossil remains are found in these countries, of animals now belonging to other lands; animals closely allied are found in the southern continents, having come down from the north, as the camel in Africa, llama in South America, the African and South American ostrich. No quadruped has ever been found native in an oceanic island, although a kind of otter is said to have been once seen in New

Zealand. Now, after their migration, they were shut up in their new homes by geological and climatic changes and destroyed the original centre. Thus, lemurs have been shut up in Madagascar; the kangaroo in Australia, where it survives through absence of carnivora.

III. *Herbiverous Series.*—Dominant, elephant. Herbiverous are always protected from carnivora in some way; size protects some, as elephant, hippopotamus, &c.; man protects the ungulates or hoofed animals: horse, cow, sheep, &c. Herbivorous animals all have a complete digestive system, and those which have not several stomachs, have a sort of superadded stomach, called cæcum, which in the hare is larger than the stomach proper. This shows the difficulty of digesting vegetable food. The stomach of a ruminant has a large receiving chamber; from this the food is taken back to the teeth to be masticated, and then, shut off by a valve, from the receiving chamber, it passes into a part called the reticulum, and from this into a kind of straining chamber called psalterium, and thence to the digestive stomach. The canine teeth are small or wanting (present in stallion, absent in mare.) The grinders are large and always keep a rough surface; the larger forms of these animals are useful, the smaller are pests. The elephant, the tusks are incisors, not canine, as are those of the walrus; they grow from a pulp, hence foreign bodies, as a bullet, may become embodied in the pulp, and as the tusk grows, be carried down into the solid bone. The molars are complex, and so arranged that if one drop out another will slide down along the jaw to take its place. The skull is full of air cells to lighten the weight; the brain is small. Cuvier says the trunk contains forty thousand muscles. The bones of the skeleton are coarse, and the limbs placed, as it were, underneath the body for supporting weight rather than for activity. Hoofed animals (ungulates) are those which have the toe enclosed by a hoof; they walk on their toes and are hence, called *digitigrades;* those walking on the soles of their feet are *plantigrades*, as the bear. Ungulates have the number of digits reduced; elsewhere we know five is the usual number; some have five in front and

four or three behind, (agouti, &c.) ; others have three or four in the hoof ; the rhinoceros has three ; tapir, four ; pig, four ; cow and sheep, three ; horse, one. This reduction gives great strength for running ; there is a constant tendency in these ungulates for the metatarsal bones to coalesce into what is called a common bone ; the teeth and jaws show the same general features ; the incisors in some have folds by which the age can be told by the amount worn away. They are divided into (A) Perissodactyles, or odd-toed ungulates, (horse, rhinoceros, &c.) ; these have the middle toe rounded on both sides ; they may have three toes (rhinoceros) or one toe (horse.) The femur of the hind limbs has two trocanters for attachment of muscles ; these animals have twenty-two or more vertebræ. (B) Artiodactyles or even-toed ungulates ; they may have four toes (hippopotamus,) or two (giraffe,) or two functional and two rudimental, (ruminants in general, as ox, deer, &c.) The femur has three trocanters, and they possess seventeen or nineteen vertebræ. As regards horns, the ruminants having hollow ones, possess a long core inside the horn ; those with solid horns have no cores ; horned ungulates have no teeth in the upper jaw.

Low.—Rodents. (See Tables.) These animals are protected from the carnivora by burrowing, hiding, &c.

Very Low.—As brute-edentata. (See Tables.)

IV. *Mutilate Series, (See Tables.)*—The whale deserves some mention ; it has a very complex circulatory system ; an extended arterial system to contain sufficient fresh blood for use beneath the water, and an equally extended venous system to carry off the blood. There are no valves in the veins of a whale. The blowing is caused by forcibly expelling air. Whalebone is a kind of strainer for the microscopic animals on which it feeds ; it is a substitute for teeth, which are, however, present in the very young animal. A whale has two lungs and can readily be drowned ; the reason it cannot breathe on land is that it is so heavy and clumsy that it cannot support its weight on land, and dies of strangulation by compression.

V. *Non-Placental Series.*—These are the lowest mammals ;

their distribution is very irregular and discontinuous. (See Tables.)

Lecture VI.—*Aves, Birds.*—Remarkable for (1) great uniformity, &c. (See Tables.) There is less variation among all birds than among the members of a single mammalian group; while there are twenty-one hundred extant species of mammals, (2) there are eleven thousand species of birds. (3) Their reptilian affinities are a most important feature; so far are they and reptiles constructed on the same plan, that Huxley has placed them together, in a series called Sauropoida, the archæopteryx, an extinct form, seems to be half-bird and half-reptile. (4) Beauty and curious instincts. Birds differ in general aspect and are of great beauty. Some, as the eastern kingfishers, birds of paradise, parrots and humming-birds, are extremely beautiful. They take great pride in exhibiting their beauty and their power of song, which is possessed in high degree by dull-colored birds. They are extremely active and vivacious; this activity is, by some, correlated with sexual habits, but seems to be due to healthy and vigorous life.

5. *Power of Flight.*—Most birds possess the power of flight, and have their anterior extremities organized for this purpose. In winter most birds migrate to warmer climates instead of the local hibernations of animals and plants.

External Skeleton—Feathers.—All warm-blooded animals must have coverings which will not conduct away their animal heat. Mammals have hair, birds have feathers, whales have blubber, and man makes his own protection. Feathers have a quill running up their centre as a support; from this quill grow out barbs laterally, and from the latter little barbules grow, held together by small hooks; these are the best-known structures to resist air. The wing feathers are so arranged that by the upward stroke the air is allowed to pass through them, while the down stroke resists its passage. The feathers growing on the wings are called primaries; those on the arm, secondaries; on shoulder, tertiaries. Feathers consist of bony matter are formed in moulds on the skin, and as they grow

out are cut and divided into barbs, &c. There are over twelve thousand skin muscles for moving the feathers; feathers are divided into groups on the body, the intermediate parts being nearly bare. Birds have no tail, or a mere rudiment; the vertebræ of the tail unite into a ploughshare bone, and on this grow the feathers commonly called the tail; the peacock's plumes are his tail coverts. So nearly are birds related in external structure that they may be classified by external characteristics only or chiefly—such as bill, claws, scales, spurs, &c.—*e. g.*, in raptores the bill is strong and hooked; in ducks it is like a spoon; in some honey-eaters the bill is very soft. Again, raptores have strong, curved claws, &c. Birds possess no teeth (except an extinct form, odontorniths), and they have a third eyelid, by which they can shut out the blinding rays of the sun; they have no external ear.

Internal Skeleton.—Bones are hollow, and admit the passage of air—hence they are called pneumatic bones; in birds the bones have a great tendency to coössify. Although in young birds we can easily detect the various bones in the skull corresponding to those of mammalia, yet in the adult the skull has coössified into a solid piece; this tendency exists all over the body. The vertebræ have no motion on each other; the heel is elevated, and the tarsal and carpal bones coössify with adjoining bones; the ribs are firmly joined by processes from one to the other; there is but one occipital condyle; each branch of lower jaw consists of several pieces, and is articulated with a quadrate bone, and by a curious system of leverage, when depressed, it raises the upper jaw; the breast bone is very large; birds of flight have a keel bone for the attachment of muscles; the better flyer the bird is the larger is its keel bone; running birds have no keel. The two clavicles coalesce into a forked bone; the scapula is small and saber-shaped, resting along the back; the coracoid process in mammals becomes a strong pillar-like bone, supporting the wings, which, for the sake of greater power, are placed just over the point of greatest weight; the ribs are united by uncinate processes; the tail vertebræ usually form a ploughshare bone (see above); birds

are bipedal; most kinds have one back and three front toes; climbers have two in each place; one species has all four in front; phalanges of toes regularly increase in number; back toe has two joints, second toe has three, third four, fourth five; some have the order 2–3–4–4. The front limbs are modified as wings, and never have more than three digits; thumbs rudimentary.

Soft Parts.—(See Tables.) We add: the pectoralis major muscle gives the wing its down stroke, while the pectoralis minor just under it sends up a tendon through a hole in the bone, and acting as if over a pulley, pulls the wing up, though itself pulling downwards. The lungs are fixed to the walls of the thoracic cavity. The stomach of raptores resembles the mammalian stomach.

Sub-Divisions of Birds.—(See Tables.)

Lecture VII.—*Pisces (Fishes.)*—Reptiles and batrachians will be passed over with a very slight notice, as they have been sufficiently described before. Snakes possess no limbs, though some rudiments are formed in certain species, of hind limbs. The body is regular in shape, tapering to a point gradually. The jaws are loosely set together, and are capable of enormous distension; the arrangement of the viscera is an example of most beautiful economy of room; the heart is situated just in front of the liver and lung; there is but one lung, and it is very curious; the forward part contains the blood, while the hind part consists solely of air-cells, designed to retain a reserve supply of fresh air while the snake is swallowing, for it swallows such large bodies that it is impossible for it to breathe in the act. Snakes are exceedingly tenacious of life; they progress by the finely developed muscles of the body-wall moving plates attached to the under surface of the body.

Fishes.—The most ancient vertebrates, being of the primary age, often called the "age of fishes," the secondary age being called the "age of reptiles," and the tertiary the "age of mammals." They are nearest to the embryonic characters of vertebrates. The neck arches remain in the form of gills; the ver-

tebral column contains much notochord, principally in cavities between the successive vertebræ, and the muscles retain their segmentation; they are boot-shaped for water life.

1. *The Respiration is by Gills.*—These are plates or frames, through which blood vessels ramify, and are exposed to the water; they are possessed by all fish; they are protected by gill-covers, usually four, though skates and sharks have more, placed under a skin, and are very difficult to separate. Amphibians possess gills in early life, but lose them when grown; gills never occur in reptiles, birds or mammals. Some fishes have both gills and lungs, as the mud fish, and hence in the long and frequent drouths occurring where they live, they are able to survive, buried in the mud; some fish can live out of water, the gills being enclosed so as to contain a supply. Such are the doris, the climbing perch, which ascends trees by means of its gill-covers; the carp, which is kept and fed in baskets of moist moss. An African gudgeon, of the Mangrove swamps, climbs to the roots of trees in search of food. Fish possess a swim or air bladder; a sac of air cells, representing lungs, in the higher vertebrates. Here we can trace a beautiful order of descent. In mammals the lungs are for the purification of the blood, and the blood vessels ramify to every corner; in birds, we see the large passages of the lungs terminating in air sacs; in reptiles (snakes) the entire back part of the lung is composed of air cells; while in the fish the entire lung is composed of these air cells.

2. *Heart.*—Possesses two cavities, an auricle and ventricle; connected with it is an arterial bulb, a sort of reservoir for the blood before passing into the arteries; the aortic arches are numerous. The heart is situated near the throat, which is the position of it in the higher mammals; in man there is a nerve passing downward from the head around the heart and aorta back into the neck; this has been explained by the position of the heart in the embryo, and beautifully illustrated by its position in the fish; the blood, which is cold, passes from the heart to the gills, and is there purified. Curious finger-like *cœca* or processes are observed near the liver, and are supposed to rep-

resent the pancreas. The kidneys of the fish are embryonic, and are supposed to represent the wolfian bodies ; they are two dark-red lobulated bodies lying above the air bladder close to the back-bone, and extending nearly the whole length of the abdominal cavity.

3. Internal skeleton, uniform in structure, generally composed of true bone, but in sharks it is very cartilaginous. The bones of the skull are distinct, and can readily be separated, as their edges are not serrated, but simply overlap each other. The floor of the skull and the roof of the mouth is formed by a distinct parasphenoid ; the lower jaw is hung to the skull by a very long suspensorium, an arrangement of bone corresponding to the quadrate-bone in birds, and the ear-bones in mammals. The neck is entirely absent, the head not being distinct from the body. The limbs, when they exist at all, are very simple, supporting the ventral and pectoral fins. The pelvis is unattached to the skeleton, and in the cod, &c., the pelvis-arch is thrown forward, underneath the throat ; the front limbs, where they are present, are attached to the back of the skull, and this misled Owen to regard the limbs as part of the head-formation. The hind-limbs with the ventral fins are often advanced to near the head. The limbs of a fish bear no resemblance to, or comparrison with, those of mammals, except in the fact of their segmentation, transversely and longitudinally. Notice the arm of man ; there is a transverse segment at shoulder, elbow, wrist and finger joints ; there is also longitudinal segmentation : (1) bone from shoulder to elbow ; (2) from elbow to wrist ; then the metacarpal segmentation and that of the phalanges. This segmentation is present in fish, and is best seen in the skate, whose rays are wonderfully segmented. This skate has a reasonably complete limb arrangement, having a coracoid bone and a scapula ; its spiracles are on top, and the water, thus admitted to the gills, is discharged from gill-openings below. These flat fish swim transversely, and lie in the mud ; hence, as they would have no use for an eye on the under side, both eyes are on one side ; though, in the young, they are regularly arranged. The pec-

toral and ventral fins are called paired fins; the others, unpaired fins; the latter are the dorsal, and caudal-fins. Some fishes have one, some two dorsal-fins; some, as cod, &c., have hard dorsal-fins; others, as perch, &c., have soft dorsal-fins. The tail-fin may be regular or irregular; where the tail-fin is symmetrical and regular, it is said to be *homocercal;* this is the recent type; when irregular and unsymmetrical, it is called *heterocercal;* this is the ancient and embryonic type.

4. *External Skeleton.*—Unlike the scales of reptiles, the fish's scales cannot be thrown off; the scales grow from the under skin of the animal, and are, therefore, called dermal; a reptile's scales, like the enamel of the teeth, grow upon the outer skin, and are called epidermal. Scales are of four kinds: (1) cycloid; round, regular, smooth edges; (2) clenoid; round, but with comb-like projections at the base; (3) placoid; resembling angular plates; (4) ganoid; usually with one or more projecting spines. The first class is represented by the eel, salmon, &c.; the second, by sole, perch, &c.; the third, by garfish, &c.; the fourth, by the dog-fish. The scales of fishes are of a similar formation to that of their teeth; so that the spines on some fish may really be said to be teeth growing upon the body.

5. Brain consists of successive lobes for the most part corresponding to those of higher vertibrates; the cerebral hemispheres are small, and nearly of the same size as the optic lobes.

6. Reproduction is oviparous or ovoviparous. They produce an enormous number of eggs, (salmon twenty thousand, cod nine million,) to allow for the destruction of the young; in the case of some, the female deposits the eggs, and the male fertilizes them. Some deposit a layer; they are then fertilized, then covered with sand, and upon the sand another layer of eggs is deposited, &c. Fisheries protect these deposits, which yield immense revenues.

Subdivisions of Fishes.—(See Tables.) Hardly to be placed among fishes are certain vertebrates—lampreys having no mandible, but a circular mouth; the bony skeleton is so imperfect that it can scarcely be said to exist at all. The spinal column is represented simply by a thick rod of notochord sur-

rounded by a sheath. The skull is cartilaginous, and has no movement on the vertebral column ; there is but one nasal aperture, and the gills are contained in pouches.

Vertebrates Having no Head, and no Vertebrate Skeleton.—The dorsal-chord persists in the adult forms ; respiration is performed by a perforated pharyngeal sac ; such is the lancelet.

General Remarks.—Fish possess great beauty of coloring, and of adaptation of color to habit. Near the shore they are colored like the sand, so as not to be readily seen. Those inhabiting the deep sea have dark backs to prevent their being seen by enemies from above, and their under parts are light, to defend from enemies from below. They have many curious instincts ; the flying-fish can really fly ; some build nests and care for their young ; some can give electric shocks ; fishes living in dark caves are blind. Fishes are mostly carnivorous ; the stomach of a large fish has been found containing one cod two feet in length ; this cod had in it two whitings, and these had some small fish in their stomachs.

Lecture VIII.—*Higher Invertebrates.*—By this term we designate those animals having no internal bony skeleton ; nerve system is unlike that of vertebrates, yet they are allied to vertebrates by having a true body cavity containing a true stomach and viscera detached from the body wall, and they possess organs of sensation. Such forms are the mollusks, star-fishes, lobsters, insects, &c. The tendency of modern research is to show resemblance and fundamental unity of structure with vertebrates. Ascidians have a notochord, situated in the tail, when young. An interesting fact is, that all these high-class animals seem to be derived from the structure of worms ; these have mouth, stomach, intestine, embryo of three layers, and other affinities, linking them with still higher animals.

Distinguishing Characteristics.—1. A digestive tract in centre, consisting of alimentary canal, liver, intestines winding and escaping at the anus. (The dark matter in an oyster is the liver.)

2. *Heart at Back*, (*dorsal.*)—The respiration is usually by gills, though the common snail breathes by lungs. In the fresh-water mussel the intestines pass through the heart; the lobster's heart is immediately under the shell of the back, so that it can be exposed by carefully removing the shell. The heart receives the blood from the gills and distributes it throughout the body; the very opposite of the process which takes place in fishes; in the tentacled mollusks, (tentacles are on the back in place of the shell,) these tentacles are the gills. The circulation is locunar, that is, the blood is not contained in closed blood vessels, but escapes and bathes the body so as to nourish it.

3. (See Tables.) We add: a ring of nerve matter surrounding the throat, unites in two large ganglia, the præsophageal ganglion, which constitutes the brain, and the postæsophageal ganglion.

4. *Reproductive Organs.*—The sexes are united in the same individual; yet, though the same animal is thus both male and female, it has not the power of self-fertilization; some are parthenogenetic; that is, they can reproduce without fertilization; the drones or male bees are all hatched from unfertilized eggs. Some of the higher invertebrates are parasitic; they have, then, no alimentary canal, no organs of motion; they have, however, reproductive organs and masses of eggs. Formerly it was supposed that they had no generative organs or eggs, and the discovery of these was a blow to the hypothesis of spontaneous generation. The young possess organs of locomotion; there is but one parasitic vertebrate; a fish, parasite in sponges.

Sub-Kingdom Mollusca—Shell-fish and snails, non-segmented shell fish, land shells. It is not easy to give a definition; but we may say "a mollusk is an animal whose body consists of a soft mass with no transverse segmentation or limbs, loosely attached to shell, which may have one, two, or many valves, and which is capable of enlargement." Some have no shell, and the shell of slugs is concealed under the skin. The distinguishing characteristics are:

1. *The Mantel.*—The body wall grows out into an extension,

like a coat tail; this is called the mantel; in a snail, it grows up to the shell, and forms, enlarges and adorns the shell by depositing layers of coloring matter on a pearly deposit; this mantel forms the pearls in pearl-bearing mollusks, by depositing pearly matter over a grain of sand in the shell, this grain irritating the body. The mantel of the fresh-water clam seems to be extended into the form of a syphon at the anal opening; one branch to draw in water to the gills, the other to expel it through the anus; the muscles working the syphon leave their impression upon the shell.

2. *Foot.*—The floor of the belly is flattened into a sort of muscular disc, by which the animal can progress; in the cockle, the foot is so prominent as to enable it to leap over the sand or bury into it; they can also move in water, as the comb-shell, by opening and closing the valves of their shell; this shell is the emblem of the crusades, being found in great numbers along the way to the Holy land; it is also the emblem of St. James.

3. *Bilateral Symmetry.*—The right and left sides are alike, yet sometimes the symmetry is disguised by compression inside of the shell, as the comb-shell, one side of which is flattened; in the snail and other univalves, the left side grows the more rapidly, and forms so complete a spiral that the anus is brought around to one side; some form a right-hand instead of a left-hand spiral. The heart has two or three cavities; they possess cilia. The alimentary canal is complex, and bent upon itself.

4. *Nervous System Irregular.*—It consists of three pairs of ganglia—the cerebral, pedal and visceral, with uniting cords—*heterogangliate*—that is, irregularly disposed.

Reproduction, bi-sexual or hermaphrodite, see above.

In the adult structure there is great variation. Attempts to corelate mollusks are based upon embryonic growth, which is as follows: They are all alike in the egg; next, they begin to show the following features: (1) ciliated bands in all but cephalopodia; these cilia enable them to move; this band forms the *velum;* a vermian characteristic also; the clio, (!) the food of the whale, retains the velum throughout its life. (2) Up the

other extremity and on the dorsal side a thickening of the skin takes place and forms the mantel. (3) A thickening on the ventral side forms the foot. (4) A development peculiar to the fresh water mussel; in these there is found a small animal now proven to be the young, situated in the mother's gills. It appears to consist of two shells united by muscular bands, from which grows a cord. At the extremities of each shell is a little toothed hook, with a small tentacle at its base. When cast off from the mother, with its cord it seizes a small fish, and the skin of this fish growing over it, it remains until the mussel is developed. These animals may be thus divided into various groups and classes by means of distinguishing characteristics.

Division I.—Odontophora.—These creatures possess a head and a lingual ribbon with spines or teeth along the sides.

Class 1.—*Cephalopoda.*—Cuttle fishes, nautilus, ammonite, &c. The foot is prolonged into tentacles around the mouth, and the tentacles are provided with sucking discs; they have a sort of break at the mouth, and a kind of internal, though not vertebrate skeleton, as seen in the "cuttle bone." The wings of the paper nautilus were once thought to be used as sails, but they are to protect the delicate shell in which the young are carried; mode of fertilization is very peculiar; one limb or tentacle of the male becomes long, swelling and whip-like; it is then cast off from the body, and is deposited in the mantel of the female. Sepia, the writing fluid of the ancients, was obtained from the cuttle.

Class 2.—*Pteropoda.*—Represented by clio, mentioned above.

Class 3.—*Gasteropoda.*—Univalve or multivalve shells. The foot becomes the organ of locomotion under the belly. The sand snail hibernates, covering the mouth of its shell with mucus; the eggs are of wonderful vitality; they can be roasted, frozen, glued to a tablet, and still be fertile, as actually happened in the case of an African snail in the British museum. The snail can restore the head, tentacles and piece of shell when broken off; the intestines are coiled so as to correspond with the shell; the liver is at the top of the shell, and the anus is on one side; the

tongue, with its lateral saws, is used to cut vegetable matter. (Subdivisions. See Tables.)

Division II.—Acephala.—No head or tooth-bearing organs.

Class 1.—*Tunicata.*—(See Tables.) We add: The mouth opens into a capacious pharyngeal respiratory sac. The larvæ are provided with tails, and are allied to the vertebrates by having in the tail a portion of the notochord, called, from its position, urochord; the heart is tubular, open at both ends, and its beatings are often reversed, the blood flowing in and out of either end.

Class 2.—*Polyzoa.*—(See Tables.) These animals usually form moss-like or coral-like calcareous or chitonous masses, each cell containing an animal. The digestive tract is flexed and the anus is situated near the mouth, which is surrounded by tentacles; they have no heart.

Class 3.—*Brachiopoda.*—(See Tables.) They are a sort of shelled worms, the shells being bivalve, and the valves ventral and dorsal. They have two spirally coiled arms, with dense ciliated cirri, and capable of reaching out beyond the shell's edge. Alimentary canal, mouth opening between the arms, an æsophagus, stomach with liver mass on each side, and a short intestine ending in a blind sac; no circulatory system, the blood being impelled by ciliary action alone. No eyes in the adult, but they exist in the larvæ of some species; sexes distinct; the respiration is mainly carried on by the mouth and arms.

Lecture IX.—*Higher Invertebrates, (continued.)*—Sub-kingdom arthropoda includes insects, spiders, crustaceans. Body consists of segments; nervous system regular; ganglia at regular intervals along the belly; appendages are added, (never hollow or jointed in worms); limbs of worms are the spines; the limbs are *articulated.* Some groups, as the centipede, have many limbs. In the mouth, the limb answer the purpose of jaws; still further forward are the anterial limbs; others are for the eyes; the limbs are varied for different purposes. Insects have no belly limbs in the adult. The stinger of the wasp is a limb, as are also the antennæ and jaws.

1. *Insects.*—Shells of all arthropods are made of chitine; the shell kept in caustic potash is destroyed, except the chitine; the hinges in the body are caused, not by the discontinuity of the shell, but by the softening of the chitine, which has in these regions no deposit of lime. Outgrowths may proceed from the trunk. Inside the shell, but outside of the body are the gills of the lobster, twenty in number; these outgrowths have a double plate of chitine, and between them is soft matter. The wings of insects, and the soft parts of the shell, bulge out like a bladder and then collapse, forming a double sheet. Ingrowths—These are processes from outer wall to the inner, to support the parts of the animal (the endo-skeleton.) The skeleton of the bee forms a lining to the alimentary canal, so that it can have teeth in the stomach; the stomach of the crayfish is lined with chitine. The breathing tubes are openings in the body; these tubes are lined with spirals of chitine; all these parts throw off chitine when moulting. [Class 1 includes air-breathing arthropods.]

Class 2.—*Water-breathing Arthropods.*—Barnacles, when young, swim, adults are fixed, and their limbs are turned into contrivances for pushing water into the limbs and food toward the mouth.

(Upon the whole of the above lecture the printed Tables should be consulted.)

Lecture X.—*Lower Invertebrates.*—Polyps, corals and sponges belong to this class. Fresh water polyps. The hydra is the type of these; it lives in fresh-water, and looks like a speck of jelly on a plant; it can stretch out its body, like a tentacle, for prey; has radiations about the mouth; no eyes; head, alimentary canal; it has neither limbs nor organs of respiration; no nervous system has been detected, except in a few groups. Their general form is radiated; hence their former name, radiata. In 1744, Trembley, a Swiss, called attention to the form of the animal, that it resembled a ball; then it unfolded. All mutilation does not destroy life; if it be cut in two, each part makes another animal; it may be cut as often as we please, and

yet each part will grow into a complete animal; when turned inside out, it will continue to live in that condition. The body-cavity acts as a stomach; it is like a sac, with a double wall; the outer wall consists of pyramidal cells; the cells forming the inner wall are amœboid. The chief specialized marks are (1) tentacles; there are eight of these; (2) they have fine hairs coiled inside a case; these can be extended, and their sting is poisonous, although we can't detect the poison of the smaller forms; (3) they increase by budding; the young is at first attached to the mother; sometimes several generations appear before a separation has taken place. (Some compound forms.) (4) Toward the end of the season the reproductive elements appear on the outer wall. (5) Embryonic development—the germ cell divides and becomes planula, afterwards gastrula; a double wall, with mouth and cilia; it thus corresponds to the germs of higher animals. Other polyps—compound forms; some compound forms unite physical functions; the cell cavities in aggregates are continued through all; some grow like a bed of moss on the outside of the shell of the hermit crab, which is never found except in its shell covered by these hydræ. Ozeanic hydrozoa—free swimming medusa; produced from attached forms; these forms, one-half inch in size, give off buds; they swim by expanding and contracting; they contain eggs; many jelly fish are egg baskets; generation, alternate.

Class 2.—*Actinozoa.*—The cavity of the body is central, with side chambers, like alcoves; the sea anemone, rather large, and have no hard skeleton; they produce a supporting skeleton, composed of lime carbonate; the red corals live outside of their shell; branching and fan corals have a skeleton and cortex; the limestone secretions come from the stone coral. Corals are not insects, and do not build; the skeleton is prepared without volition. Coral polyps can't live below thirty fathoms of water.

Class 3.—(See Tables.)

Lecture XI.—A drop of water, when pure, has no animalcules in it; it contains these only when it is filled with vegetation; those which do appear do not belong to one group only,

but are heterogeneous. They have certain features which distinguish them as protozoa, the lowest sub-kingdom of animals.

About 1839 it was established that all animals and plants were built of cells ; it was at first thought that every cell must have a wall, but the wall is not essential, *e. g.*, the egg of a fowl is a large cell, with nucleus, albumen, &c. ; the yolk is protoplasm. All animals are produced from cells, dividing and forming layers ; some cells become flesh, nerves, blood, bones, &c. Protozoa are only a single cell, and this breaks up into a number of cells, each cell becoming a separate protozoön. They reproduce by encysting process ; sometimes they are attached to one another by spines, yet they remain distinct ; all are aquatic and microscopic.

Positive Characteristics.—(1) Animals made up of cell ; (2) the cell is of simple animal matter, (sarcode) like flesh, looks like jelly, but has the powers of flesh, transparent, albuminoid matter, or protoplasm, of which the white of an egg and white blood-corpuscles consist ; (3) sarcode made up of two parts : the inner part, endosarcode, being fluid ; the outer part, exsosarcode, is firmer ; in infusoria, it is so firm that it is always the same shape ; (4) many shells, some of chitine, some of lime or silica, or agglutinized grains of sand ; the shells of foraminifera are perforated ; when alive a needle-like process juts out from these perforations, and over these spines the sarcode streams. Radiate shells are flint, and very beautiful ; spines radiate ; some, as amæba, are naked ; (5) nucleus, a piece harder than the rest, and placed near the hind-parts, has something to do with reproduction ; (6) contractile vesicles have a double function : to get rid of water, and for respiration ; when the vesicles enlarge it, then expels the water ; sometimes the animal draws in food, water comes in and passes to this vescicle, there are two of these vesciles.

Functions of the Cell.—Contractibility of jelly-flesh, which moves constantly. Irritability of cells—something like a purpose in their actions ; when touched, it seems to change its position, sensibility being thus shown. Automatic action—

motion always in the same direction. Digestive process—surplus expelled at posterior part; oxygen is drawn from the water, and carbonic acid formed, is the source of heat and force. Reproduction—(*a*) some divide; (*b*) most frequently one buds from another; (*c*) congregation, two just alike combine into one more vigorous than either, and can then undergo more changes; (*d*) encysting, most characteristic. No spontaneous generation is known; life is a mystery known only by its effects; it has been defined as the totality of phenomena, but this is no real definition.

Classification of Protozoa.—(See Tables.) We add, infusoria, highest and most abundant species, having hard outer-parts; some can be seen by the naked eye. Gregarinida have no processes.

Foraminifera.—Shells become rocks; the ooze of the Atlantic is filled with the shells, making limestone; they are more numerous than coral; sponge dust is composed of these shells.

Monera.—Have no nucleus; perhaps it may yet be discovered.